

A PRACTICAL MANUAL ON METHODS OF SOIL TESTING

**B.Sc. (Horticulture)
(2013)**

G.R. RATHIYA



**COLLEGE OF HORTICULTURE, RAJNANDGAON
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)**

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G. R. Rathiya

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PRACTICAL 1. COLLECTION AND PREPARATION OF SOIL SAMPLES

The importance of having a representative sample can be well realized because of only a very small fraction of soil mass of the field is used for analysis. While collecting samples the following points are to be borne in mind.

Where surface samples are collected for advisory work. it must be represent the area. a field can be treated as a single sampling unit only if it is appreciably uniform. The number of samples to be collected from a field would depend upon the variability of the land. Variation in slope, colour texture, crop growth and management should be taken in to account and separate sets of composite samples need to be collected from each of such area. Recently fertilized plots, bunds, and channels. Marshy spots and areas near trees or compost pits or Other Institute non-representative locations must be avoided during sample if taken properly, could be good enough for an area of about 2 to 3 hectares. On the contrary, if the farm has an undulating topography, bottomlands, uplands and slopes, separate sample is to be drown form each unit,

The root penetration habit of plants is to be considered for ascertaining the depth of sampling. For the field crops, a sampling depth of 15 to 20 cm is desired. For pasture corps and for horticultural crops, samples from different depth or layers depending upon the rooting depth of plants may be needed, For estimation of immobile nutrients like P, K. and Ca, soil samples to tillage depth can give satisfactory results, however, for analysis of mobile nutrients like No_3 and So_4 , soil sample should be taken to a depth of 60 cm. for soils under intensive cultivation, sampling should be done every year but if only one crop per year is raised, sampling once in three years is sufficient the time of sampling should be same at each year.

Sampling Depth

Sampling depth should be determined to represent the root zone that the plant will draw from, but should also be consistent with the sampling depth used in developing the calibration data set to be used for interpreting the soil tests.

Prescribed depth of soil sampling

Field crops	15-20 cm
Deep rooted crops	30-60 cm (Sampling at different depths or layers is ideal)
Forage or pasture crops	8-10 cm
For immobile nutrients (P, K, Ca and Mg)	Sampling at tillage depth
Nitrate, Sulfate	60 cm (when the biological activity is low)
Saline alkali soils	Salt crust should be sampled separately and the depth of sampling should be recorded

SOIL SAMPLING

First traverse the field to be samples, note the variations in slope, colour, texture, management and cropping pattern. Demarcate the field into uniform portion, each of which must be samples separately. To obtain a composite sample, a zigzag pattern of sampling should be followed. A representative composite soil sample can be composed of 8-20 sub-samples from piece of a uniform filed. Sub-samples should not be collected from area, which is within 50 cm. from the border of the field. The soil so collected should be thoroughly mixed (by hand) on a clean piece of cloth or paper and about 500 g of the composite sample should be retained the soil should be quickly dried at room temperature of in shade and store in bags. Before sending samples to the laboratory for the analysis it should be properly labeled with respect to field number of local name of the field, date of sampling, depth of sampling and the name of cultivator along with complete postal address.

Collection of soil samples from a profile

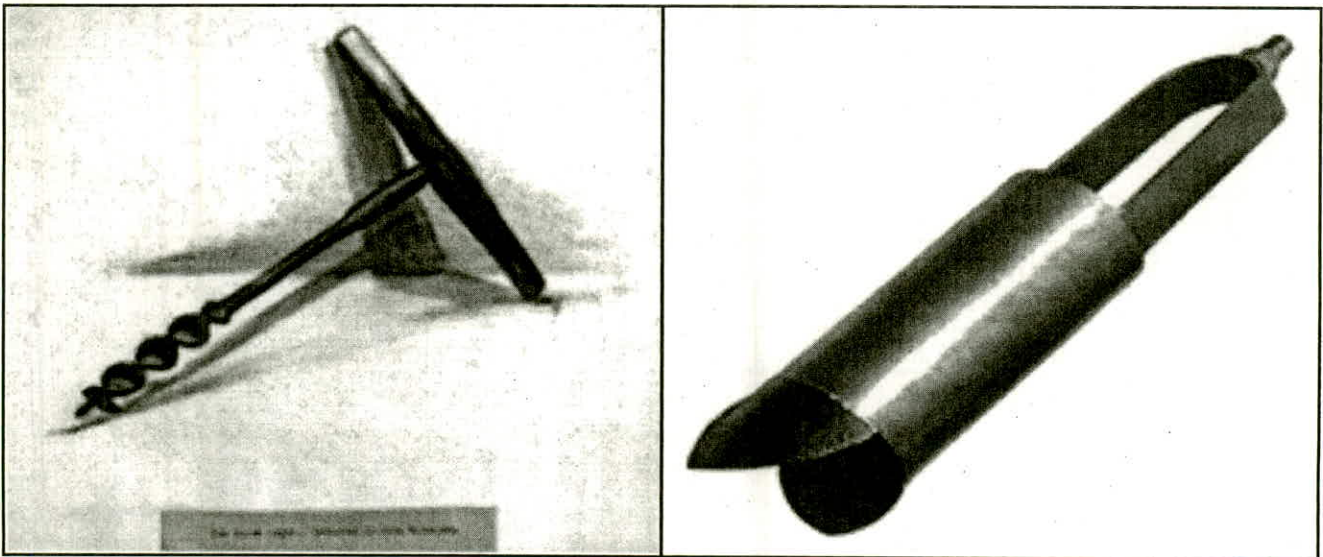
After the profile has been exposed, clean one face of the pit carefully with a spade and note the succession and depth of each horizon. Prick the surface with a knife or edge of the spade to show up structure, colour and compactness. Describe the profile as per the standard terminologies. Use the Munsell colour chart for noting the colour and find out the texture by feel method.

Collect samples from each horizon by holding a large basin at the bottom limit of the horizon while the soil above is loosened by a khurpi. The sample is mixed and transferred to a bag after labeling.

SAMPLING TOOLS

Spade and a cut away soil sampling tube are the most commonly used tools for taking a soil sample. However, any one or two of the following tools can be used satisfactorily for this purpose.

1. Soil tube
2. Screw type auger
3. Post hole auger
4. Spade and
5. Sickle



For sampling soft and moist soil, the tube auger, spade or khurpi is quite satisfactory. A screw auger is convenient on hard/ dry soil. While post hole auger is useful for sampling in excessive wet areas/rice fields. If a spade or khurpi is used, a V shaped hole may be dug up to the plough layer and a uniform thick slice of soil mass may be taken. Augers are necessary for sampling from lower depths.

PRECAUTIONS FOR SOIL SAMPLING

Do not sample from

1. Farm lanes and field borders
2. Fertilizer bands in row crops
3. Any area which is distinctly different from the dominant soil type in the field such as eroded spots, small saline areas, sandy ridges unless these areas are sampled separately.
4. Dead furrows and headlands
5. Old manure piles or old straw stack bottoms
6. Locations where brush piles have been burnt.

SOIL PREPARATION

The air-dry soil is normally passed through 2- mm sieve for analysis. Before sieving, the soil clods should be lightly crushed in wooden mortar and pestle. Plants residues, gravels and other foreign matter retained on the sieve should be discarded. If the gravel content is substantial. It should on the sieve should be discarded. If the gravel content is substantial, it should be noted separately. For special determination for which it is necessary to weigh out small quantities of soil i.e. organic carbon, CaCO_3 and chemical analysis, it is desirable to grind a representative sub-sample and sieve it through 0.5-mm (32-mesh) sieve.

For micronutrients like copper iron, manganese and zinc, a brass sieve should be avoided and aluminum or plastic sieve with nylon netting should be used.

Soil samples should preferably be stored in clean cloth or polyethylene bags the bags can be reused after washing and drying. Relevant information regarding slope, drainage, irrigation, previous cropping history, fertilizer used for previous crops and proposed crops etc. of the field should be provided with each sample.

PRACTICAL 2. DETERMINATION OF MOISTURE CONTENT IN SOIL

Moisture content in a soil may be measured in a number of ways. Gravimetric method is the simplest and widely accepted method for measuring soil moisture. In this method known quantity of soil sample is placed in an oven at 105°C and it is dried to constant weight. The difference in weight is considered to be water present in soil sample. It is generally expressed as moisture content in percentage.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight}}{\text{Oven dries weight of soil}} \times 100$$

Equipment required

1. Sampling auger
2. Moisture cans
3. Electronic balance or balance with weights
4. Hot air oven
5. Desiccators

PROCEDURE

Weigh the empty moisture can. Collect composite soil sample and mix thoroughly. Put about 50 to 100 g soil sample in moisture can immediately and close it with right fitting lid to prevent loss of moisture by evaporation. Note the weight of the can along with soil and lid. Now remove the lid and place moisture can in oven to a constant weight at 105°C . Allow the sample to cool for some time in oven itself. Then remove the can from the oven and close it with its lid and put it in a Desiccators for further cooling. Finally weigh the closed can along with the oven dry soil.

Observation

- | | |
|--|---------|
| 1. Wt. of empty moisture can. | A g |
| 2. Wt. of moisture can along with moist
Soil sample | B g |
| 3. Wt. of moisture can+ oven dried soil | C g |
| 4. Moisture content in soil | (B-C) g |
| 5. Weight of oven dried soil | (C-A) g |

Calculation

$$\text{Percentage moisture in soil} = \frac{(B-C)}{(C-A)} \times 100$$

PRACTICA 3. DETERMINATION OF BULK DENSITY (DB)

Soil bulk density is defined as the ratio of the soil mass of oven dried solids to the bulk volume of the solids plus pore space. An ideal soil contains about 50% by volume of solids and 50% pores. Liquid (water) and gas occupy the pores. These air and water filled pores vary reciprocally with the moisture content of the soil and are indirectly dependent on texture and structure. Apparent density and bulk density are synonymous terms expressing the weight per unit volume of naturally occurring soil. As for the true density and generally varies from 1.02 to 1.18 Mg/m³.

PROCEDURE

Weigh a large weighing bottle of about 50 ml capacity without the stopper. Fill it up with soil flush up to the brim tapping the bottle about 20 times and weigh again. Remove the soil and now fill the bottle with water by means of burette or graduated pipette and note the exact volume of water needed to fill the bottle. The apparent bulk density is obtained by dividing the weight of the soil by the volume of the soil.

Calculation

Weight of empty bottle = w_1 g

Weight of bottle and soil = w_2 g

Weight of soil = $w_2 - w_1$

Volume of the soil or volume of water needed to fill the bottle = vml

Bulk density = $\frac{w_2 - w_1}{V}$ g/cm³

Potassium hydrogen phthalate (A.R. grade) 0.05 M solution gives a pH of 4.0 : A stock solution is prepared by dissolving 61.24 g of potassium hydrogen Phthalate (A.R. grade) in warm water and make the volume up to one liter. 2-3 drops of toluene are added in to solution to prevent growth of mould, A dilution of 10-ml of this solution with 50 ml of distilled water gives 0.05 M solution.

2. pH 8.0 buffer solution : dissolve 19.45-ml of 0.2 M Na_2HPO_4 with 0.55-ml of 0.1 M citric acid. It is necessary to prepare fresh buffer solutions after a few days as the buffers do not keep for long.

Procedure (soil to water ratio 1:2)

1. Transfer 20 g of soil in a 50 ml beaker
2. Add 40 ml of distilled water and stir the suspension intermittently with glass rod for 30 minutes.
3. Standardize the pH meter by using a buffer solutions having 4.00 and 7.00 pH. Wash the electrode with a jet of water.
4. Insert the electrode in to the soil suspension and record the pH value.
5. Remove the electrode from soil suspension and wash the adhering soil particles on the electrodes with a fine jet of water. Wipe the electrode with tissue paper or muslin cloth and proceed for next sample.

Precautions:

1. Put the electrode always immersed in distilled water when not in sue.
2. The reference electrode must always be filled with saturated solution of KCl.
3. Change the distilled water daily in which the electrodes are immersed.
4. The soil suspension must be stirred well just before the electrodes are immersed.

Based on the pH value the following ratings may be adopted

Rating	pH range	
1. Extremely alkaline	<9.0	Characteristic of highly alkaline soils requiring reclamation measures.
2. Strongly alkaline	8.4-9.0	
3. Moderately alkaline	7.6- 8.3	Suitable for many of the agril crops and pH beyond 8 to 8.3 can be tolerated by
4. slightly alkaline	7.1-7.6	Crops like rice, Lucerne.
5. Nearly neutral	7.1 -6.5	
6. Slightly acid	6.0-6.5	Characteristic of many red & literati soil indicating deficiency of calcium and low in base saturation
7. Moderately acidic	5.3-6.0	
8. Strongly acidic	4.5-5.2	Characteristics of soils of the humid regions where annual rainfall exceeds 80 of true late rites of the Malabar cost.
9. Extremely acidic	>4.5	

PRACTICAL 6.

DETERMINATION OF ELECTRICAL CONDUCTIVITY OF SOIL

Specific electrical conductivity of a solution is directly related to its ion content. It is measured with a conductivity cell and expressed in millimhos or millisiemens (mS) per cm or dS m⁻¹ (desi-siemens per meter). Conductivity cell shows individual Deviations, hence it is necessary to calibrate the conductivity meter before use. The calibration of the conductivity meter is made with 0.01 N KCl Solution.

Reagent

Standard potassium chloride solution: Dissolve 0.7456 g of dry potassium chloride (A.R. grade) in distilled water and made the volume up to one litre, At. 25°C it gives an electrical conductivity of 1.41 mmhos/cm or 1.41 dS m⁻¹ the conductivity meter is to be calibrated and cell constant determined with the help of this solution. Even if the scale is given directly in mmhos/ cm it is necessary to check the instrument with this solution.



Procedure:

1. Transfer 20 g of the soil in 50 ml beaker
2. Add 40 ml of distilled water or deionized water and stir the suspension intermittently for half an hour and keep it 30 minutes without touch
3. Insert the conductivity cell in suspension solution and note the electrical conductivity of the sample.
4. Wash the conductivity cell using a fine jet of water.

Note : Always immersed conductivity cell (electrode) in distilled water after cleaning properly.

PRACTICAL 7. DETERMINATION OF ORGANIC CARBON CONTENT OF SOIL

(Walkley and Black method)

The organic matter plays an important role in supplying nutrients and water to the plants and also by providing good physical conditions to the soil system. This method estimates the organic carbon of the soil to the extent of 77 % of the total quantity of organic carbon through oxidation and hence, to get the total amount of organic carbon, the per cent organic carbon is multiplied by 1.3. Factor (correction in factor 100/77). The soil organic matter present in soil the value is multiplied by Van Bemjmelan factor i. e. 1.724. Recently Broadbent (1953) suggested 1.9 and 2.9 and 2.5 as a multiplying factor for surface and sub-surface soils respectively to convert percentage of organic carbon to organic matter.

Principle

The soil organic matter (humus), which contains about 48 to 58% organic carbon, is oxidized by chromic acid utilizing the heat of dilution of sulphuric acid. The unreacted chromic acid is determined by back titration with standard ferrous ammonium sulphate solution using diphenylamine / ferroin as an indicator.

Reactions

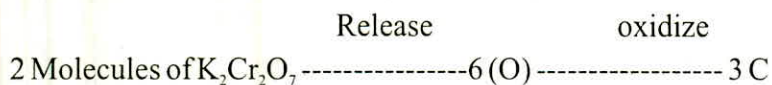
During digestion

1. $2K_2Cr_2O_7 + 8H_2SO_4 = 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 6O$
2. $3C + 6O = 3CO_2$

During titration

3. $K_2Cr_2O_7 + 7H_2SO_4 + 6FeSO_4 = K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$

Two molecules of $K_2Cr_2O_7$ give out 6 atoms of nascent oxygen in presence of H_2SO_4 . Reaction indicates that the six atoms of nascent oxygen released from two molecules of $K_2Cr_2O_7$, which are required for oxidation of three atoms of carbon.



$$2(294) \text{ g } K_2Cr_2O_7 = 3(12) \text{ g carbon}$$

$$49 \text{ g } K_2Cr_2O_7 (1000 \text{ ml of 1N solution}) = 3 \text{ g carbon}$$

(Equivalent wt. of is 49)

$$1000 \text{ ml of 1 N } K_2Cr_2O_7 = 3 \text{ g carbon}$$

$$1 \text{ ml of 1 N } K_2Cr_2O_7 = 0.003 \text{ g Carbon}$$



Reagents

1. **Potassium dichromate solution (In):** dissolve 49.04 pure crystals of $K_2Cr_2O_7$ in distilled water and dilute to 1 liter:
2. **0.5 N ferrous sulphate solution :** Dissolve 139 g $FeSO_4$ (A.R. grade) in distilled water and add 15 ml conc. H_2SO_4 and dilute to 1 litre. Ferrous ammonium sulphate can also be used. To prepare 0.5 N solution of FAS, dissolve 196 g of salt in 800 ml distilled water containing 20 ml conc. H_2SO_4 and dilute to 1 litre.
3. **Conc. Sulphuric acid :** Not less than 96 % purity.
4. **Ortho phosphoric acid:** 85%
5. **Diphenylamine indicator:** Dissolve 0.5 g diphenylamine in a mixture of 100 ml conc. H_2SO_4 and 20 ml water.
6. **Ferriin indicator (0.025 N):** Dissolve 1.485 g orthophenanthroline monohydrate and $FeSO_4 \cdot 7H_2O$ in water. Dilute to 100 ml (During titration colour of the solution changes from dull green to chocolate red.) The indicator is also available as prepared solution Addition of 3 to 4 drops of this indicator is sufficient. (Note: Ortho-phosphoric acid or sodium fluoride is not required when ferriin solution is used as an indicator)

Procedure

Transfer 0.5 to 1.0 g finely ground soil sample passed through 0.5 mm sieve without loss into 500 ml conical flask Add 10ml of 1 N Potassium dichromate solution by means of pipette followed by 20 ml conc. H_2SO_4 with measuring cylinder, shake the content of the flask for a minute or two and set aside on an asbestos sheet for exactly half an hour, At the end of the period add 200 ml distilled water, 10 ml ortho phosphoric acid and 1 ml diphenylamine indicator. Titrate the contents with std. ferrous ammonium sulphate or ferrous sulphate till colour flashes from blue violet to brilliant green. Similarly a blank is run without soil.

OBSERVATION

1. Weight of soil taken w g
2. Vol. of 1 N pot. dichromate added 10 ml
3. Vol. of 0.5 N FAS required to neutralize 10 ml of 1 N pot. dichromate solution - (Blank. without soil) B ml
4. Vol. of 0.5 N FAS required for soil R ml
5. Vol. of 1 N $K_2Cr_2O_7$ solution used for the oxidation of organic carbon present in the sample 10 (B-R/B)

Calculations

$$\text{organic carbon (\%)} = \frac{10(B-R)}{B} \times 0.003 \times \frac{100}{\text{wt of soil (g)}}$$

$$\text{organic matter (\%)} = \% \text{ Org. Carbon} \times 1.724 \times 1.3$$

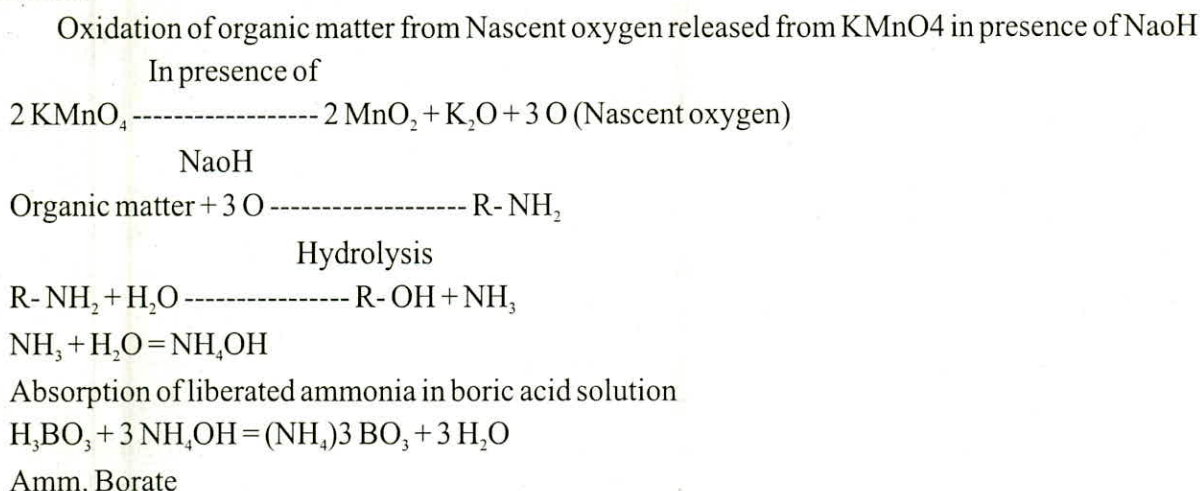
PRACTICAL 8.

Determination of Available Nitrogen in Soil (Alkaline Permanganate Method)

The nitrogen supplying ability of the soil is determined by distilling soil with alkaline potassium permanganate solution. During the distillation, easily utilizable and amino- N hydrolyzed N liberated as ammonia, is measured this serves as an index of the available nitrogen status of soil.

Principle: The easily utilizable organic nitrogen present in the soil is oxidized by KMnO_4 in presence of NaOH . The ammonia released during oxidation is absorbed in boric acid to convert the ammonia to ammonium borate. The ammonium borate formed is titrated with standard H_2SO_4 .

Reactions



Titration

Ammonium borate formed during absorption of liberated ammonia in boric is determined by titrating it with std. H_2SO_4 $2(\text{NH}_4)_3 \text{BO}_3 + 3 \text{H}_2\text{SO}_4 = 3 (\text{NH}_4)_2 \text{SO}_4 + 2 \text{H}_3 \text{BO}_3$ completion of titration i.e. neutralization of ammonium borate is indicated by change in colour from green to red.

Reagents

- Potassium permanganate (KMnO_4) 0.32 % :** Dissolve 3.2 g of KMnO_4 in 1 litre of the distilled water with intermittent shaking till it is completely dissolved. Store in amber coloured bottle and place in the dark.
- Sodium hydroxide solution (2.5 %) :** Dissolve 25 g of NaOH pellets in one litre of distilled water.
- Mixed indicator (Bromocresol green + Methyl Red) :** weigh out separately 0.01 g bromocresol green and 0.07 g methyl red and dissolve them together in 100 ml ethyl alcohol.
- Boric acid indicator solution :** Dissolve 20 g of pure boric acid (H_3BO_3) in about 700 ml hot water, Transfer the cooled solution to a 1 litre volumetric flask containing 200 ml ethanol and 20 ml mixed indicator solution After mixing the content of the flask, add approximately 0.05, N NaOH cautiously until the colour is red dish purple. Then make up the volume with distilled water up to 1 litre and mix it thoroughly.

5. **Standard sulphuric acid (0.02N):** Prepared working solution of sulphuric acid from 0.1 N Standard H₂SO₄ Solution.
6. **Liquit paraffin**
7. **Glass beads**

Procedure:

1. Transfer 20 g of processed soil sample into 1000 ml round bottom distillation flask.
2. Add 20 ml distilled water and swirl.
3. Add 2 to 3 glass beads to prevent pumping and 1 ml of liquid paraffin to prevent frothing.
4. Then add 100 ml 0.32% potassium permanganate and 100 ml of 2.5 % NaOH solution into distillation flask and immediately connect to the Keelhaul assembly.
5. Distill the contents in Kjeldahlassembly at a steady rate and collect the liberated ammonia in the form of distillate in a 250 ml beaker containing 20 ml boric acid solution (with mixed indicator) During the absorption of ammonia, pink colour of boric acid solution turns green.
6. Collect approximately 150 ml of distillate
7. Titrate the distillate with std. H₂SO₄ solution till the colour changes from green to original shade (Pink)
8. Carryout blank determination (without soil)

Observation :

1. Weight of soil sample taken w.g.
2. Volume of std. Acid required for soil A ml
3. Volume of std. Acid required for blank B ml
4. Normality of sulphuric acid N

Calculation:

$$\% \text{ Available N} = \frac{(A-B) \times (N. \text{ of acid}) \times 0.014 \times 100}{\text{wt. of soil (g)}}$$

$$\text{Avail N (Kg/ha)} = \frac{\% \text{ N} \times 240000}{1}$$

OR

$$\text{Avail. N (Kg./ha)} = \frac{(A-B) \times N \times 0.014 \times 2240000}{\text{Wt. of soil (g)}}$$

PRACTICAL 9. DETERMINATION OF AVAILABLE PHOSPHORUS

Phosphorus in soil occurs as orthophosphate in several forms and combinations and only a small fraction of the total amount present may be available to plants, which is of direct relevance in assessing the phosphorus fertility level.

The methods are commonly used for determining available phosphorus in soils. The Olsen's method (Olsen ET al, 1954) is used for neutral - alkaline soils while the Bray and Kurtz P1 method (Bray and Kurtz 1945) is used for acid soils.

Olsen's Method (NaHCO_3)

In this method phosphorus is extracted from the soil using 0.5 M NaHCO_3 , pH 8.5 as an extractant. Sodium bi-carbonate decreases the concentration of Ca in solution by precipitation Ca as CaCO_3 , as a result, the concentration of P in solution increases. Phosphorus extracted by NaHCO_3 is estimated colorimetrically by adding ammonium molybdate and there after reducing the molybdenum phosphate complex in acidic medium, The intensity of blue color on reduction provides a measure for the concentration of P in the extract.

Reagents

- 1. 0.5 M NaHCO_3 solution, pH 8.5:** Dissolve 42 g NaHCO_3 in water and make up to 1 litre, mix thoroughly. Adjust pH of the solution to 8.5 with 20% NaOH solution (about 3-4 ml of NaOH solution per litre may be necessary).
- 2. Reagent A:** Dissolve 12 g ammonium molybdate in 250 ml of distilled water Dissolve 0.2910 g antimony potassium tartarate in 100 ml water. Add both these solutions to 1000 ml of 5 N H_2SO_4 (140 ml. Conc., of H_2SO_4 in 10000 ml water) mix thoroughly and make to 2000 ml. Store in corning glass bottle in a dark and cool place.
- 3. Reagent B:** Dissolve 1.056 g ascorbic acid ($\text{C}_6\text{H}_8\text{O}_6$) in 200 ml of Reagent A and mix. This does not keep for more than 24 hours at room temperature. prepare daily as required.

Standard stock P solution (100 ppm P): Dissolve exactly 0.439 g potassium dehydrogen orthophosphate (KH_2PO_4) AR grade (dried in oven at 60°C for 1

- h and cooled in desicator) in a half a litre of distilled water Add 25 ml of 7N H_2SO_4 and make to 1000 ml with distilled water. This gives 100 ppm P standard stock solution from this diluting it 50 times makes a 2- ppm P solution.

Procedure :

- Preparation of standard curve
1. Prepare a series of standard by taking 0,2,4,6,8, and 10 ml of 2 ppm p solution in 25 ml volume flask separately, which correspond to 0,0.16, 0.32, 0.48, 0.64 and 0.80 ppm p or ug/ ml P respectively.
- Add 5 ml extracting solution (0.5 NaHCO_3) to each flask and adjust pH as above.

- d) Dilute the contents to about 20- ml with distilled water and then add 4.0 ml reagent B.
- e) Make up the volume and measure the intensity of blue color at 730-840 nm on spectronic 20 or using red filter (660 nm) on colorimeter.
- f) Construct a graph by plotting readings on axis and conc. of p on axis.

Vol. of 2 ppm P (2 ugP/ ml) taken (ml)	Final Volume (ml)	Phosphorus (p) ug p in 25 (ml)	concentration ppm P	Colorimeter ug/ ml	reading
0	25	0	0	0	
1	25	2	0.08	0.08	8
2	25	4	0.16	0.16	15
4	25	8	0.32	0.32	30
6	25	12	0.48	0.48	44
8	25	16	0.64	0.64	61
10	25	20	0.80	0.80	90

$$\text{Factor (F)} = \frac{\text{concentration of P}}{\text{Corresponding reading of Above concentration}} = \frac{0.32}{30} = 0.01$$

Factor (F) = 1 colorimeter reading = 0.01 ppm p or 0.01 ug p/ml

B) Extraction of soil P

1. Transfer 2.5 g air dry soil (2 mm diameter) into a 150 ml conical flask.
2. Add a little Darco G 60 carbon / Activated carbon (phosphate free)
3. Then add 50 ml Olsen's reagent (0.5 M NaHCO₃ solution, pH 8.5) to maintain soil to solution ratio of 1:20 and shake on the reciprocating shaker for 30 minutes
4. Similarly, run a blank without soil.
5. Filter through whatman No. 40 or 42 filter paper into a clean and dry beaker shake the flask immediately before pouring suspension into funnel.

C) Estimation

1. Pipette out 5 ml of the above extract (NaHCO₃, extract/ filtrate) into 25 ml volumetric flask.
2. Add 1 ml of 5 N H₂SO₄, add two drops of 2, 4 paranitrophenol and add 5N H₂SO₄ drop by drop with intermittent shaking till yellow colour disappears)
3. Dilute the contents to about 20 ml with distilled water and then add 4.0 -ml reagent B.
4. Make up the volume and measure the intensity of blue colour at 730 to 840 mm on spectronic 20 or using red filter (660 nm.) on colorimeter.

Observations

- | | |
|--|-------|
| 1. Weight of soil taken for analysis | 2.5g |
| 2. Volume of extract ant (NaHCO ₃) added | 50 ml |
| 3. Volume of aliquot taken | 5 ml |
| 4. Final volume of colored solution | 25 ml |
| 5. Colorimeter reading | R |

Calculations

Colorimetric reading (F) = 0.01 PPM P or 0.01 ug P / ml (form std. curve) Colorimetric reading of unknown sample = R

Concentration of P in unknown solution = R x F ug P/ml

That means each ml of colored solution contain = R x F ug P/ml

Therefore 25 ml colored solution is prepared from 5 ml aliquot

P in 5 ml aliquot = R x F x 25 ug P

Hence 50 ml extract will contain = R x F x 25 x (50/5) ug P

As 2.5 g soil extracted with 50 ml NaHCO₃ extractant

: P in 2.5 g soil = [R x F x 25 x (50/5)] ug P

Hence p in 1 g soil = [R x F x 25 (50/5)] 1/2.5 ug p

Which is equal to ppm P in soil

1 g soil contain = [R x F x 25x (50/5)] 1/2.5x 1000 ug P

1 Kg soil will contain = [R x F x 25x (50/5)] 1/2.5 ug P

: 2240000 Kg soil i. e 1 hectare soil will contain

= [R x F x 25 x (50/5)] 1/2.5 x 1000 x 2240000 ug P

CONVERT ug P In To Kg P

$$P \text{ kg/ha} = R \times F \times 25 \times \frac{50}{5} \times \frac{1}{2.5} \times \frac{1000}{1} \times \frac{2240000}{1000 \times 1000 \times 1000}$$

1000 ug = 1 mg

1000 mg = 1 g

1000 g = 1kg

F = 0.01

P in kg / ha = R x 2.24

P₂O₅ kg/ha = R x 2.24 x 2.29

P x 2.29 = p2O3

$$P \text{ (ppm in soil)} = \frac{\text{ppm P in total volume of extract}}{\text{(R x F) aliquot taken (ml)}} \times \frac{1}{\text{wt. of soil (g)}}$$

P (kg/ha) = ppm P in soil x 2.24

P₂O₅ (kg/ha) = p (Kg/ha) x 2.29

Conversion factors P x 2.29 = P₂O₅

P₂O₅ x 0.437 = P

PRACTICAL 10.

DETERMINATION OF AVAILABLE POTASSIUM

(Neutral N ammonium acetate method)

The total potassium content of the soil varies from 0.05 to 2.5%. Only a small fraction of total K is held in exchangeable form while the rest remains in fixed or non exchangeable form. When the crops exhaust the supply of exchangeable K more K is released from the fixed reserve. On the contrary, if K is added to the soil, a major part of it enters into non exchangeable form. Exchangeable K thus tends to remain at a constant level in the soil and, therefore, is a very useful determination. Good correlation between yields and exch. K has been obtained. Exch. K, is therefore, also referred to as "available K".

Principle

The available potassium includes the both i.e. exchangeable and water soluble forms of K present in the soil. Neutral N ammonium acetate extracts both these forms from the soil. The NH_4 ion provides a sharp and rapid extraction of K from exchange complex. The potassium in extract is estimated flame photometrically.

Reagents

- 1. Neutral N ammonium acetate solution:** Dissolve 77.1 g reagent grade NH_4OAc in 900 ml distilled water, adjust pH to 7.0 with 3N acetic acid or 3N NaOH. Dilute to 1 litre.
- 2. Std. Potassium solution (1000 ppm K):** Dissolve 1.908-g oven dry AR grade crystals of KCl in 1 litre of the extracting solution.

Procedure

1. Transfer 5-g soil into 150 ml conical flask.
2. Add 25 ml extracting solution
3. Shake the content for 5 minutes on mechanical shaker.
4. Filter the contents immediately through ordinary filter paper and collect the filtrate in a beaker.
5. Dilute 5 ml of filtrate to 25 ml with distilled water.
6. Atomize the above diluted extract to flame photometer and note the reading.

Preparation of standard curve

- Check all the connections including electric, gas, air etc. and also whether appropriate filter is placed at proper place in the flame photometer or otherwise follow the instructions given in the instrument's manual.
- Adjust the fuel and air supply by using proper knobs so that there should be a bluish colored sharp cone of a non-luminous flame.
- Atomize distilled water first, then atomize blank solution (0 elemental content) and set the galvanometer reading at 0 and then atomize higher concentration and set the galvanometer reading at 100. Atomize intermediate working solutions and record the galvanometer reading. Plot meter reading as against

concentration of K of working solutions on a graph paper. Calculate F(F= Concentration of K/ corresponding flame photometer reading).

Suppose Blank (0 ppm K) is adjusted to 0 reading and 100 ppm K solution is atomize to flame photometer and galvanometer reading is adjusted to 100 reading. Intermediate solutions show proportionate readings. Then.

$$\text{Factor} = \frac{\text{concentration of K}}{\text{Corresponding reading}} = \frac{100}{100} = 1$$

Hence, 1 reading will be equal to 1ppm K or 1 ug K /ml

Reading of the soil extract is R

Soil extract will contain (R x F) = (R x 1) ug K / ml

Hence, 25 ml soil extract will contain (R x 1 x 25) ug K

Potassium contain in 5 g soil is extract with 25 ml extract ant

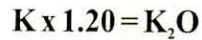
5 g soil will contain = (R x 1 x 25) ug K

1 kg (1000 g) will contain = (R x 1 x 25) x 1000 ug k

1 hectare soil will contain = (R x 1 x 25) x 1000 x 2240000 ug k

[weight of 15 cm soil in one hectare = 2240000 or 2.24 x 10⁶ kg]

Conversion of ug K to kg K



1000 ug = 1 ml

1000 ug = 1 g

1000 g = 1 kg

$$(R \times 1 \times 25) \times 1000 \times 2240000$$

$$\text{k kg/ha} = \dots\dots\dots = R \times 11.20$$

$$5 \times 1000 \times 1000 \times 1000$$

K₂O kg / ha = R x 11. 1. 20

Calculation

$$\text{Avail k (kg/ha)} = (R \times F) \times \text{vol. of extract} \times \frac{2.24 \times 10^6}{\text{soil weight (g)} \times 10^6}$$

$$\text{Avail K}_2\text{O (kg/ha)} = \text{Avail K (kg/ha)} \times 1.20$$

Where R = reading F = conc. of K/ corresponding riding and DF = dilution factor, if only.

PRACTICAL 11.

Pretreatment and Dispersion of Soil for Particle - Size Analysis

Pretreatment of the soil sample is mainly done to obtain maximum dispersion and to maintain this dispersion during the process of making the particle - size distribution analysis .

The organic matter in the soil is oxidised by hydrogen peroxide which was first used by Robinson (1922). Efficient use of H_2O_2 requires an acidic medium. Which means that the soil needs prior treatment for removal of carbonates and soluble salts imparting an alkaline reaction to the soil suspension . To overcome the effect of MnO_2 Olmstead et al . (1930) Proposed the addition of a small amount of glacial acetic acid to reduce MnO_2 to manganous form specially in non calcareous soils.

After the Peroxide treatment the soil is treated with dilute HCl. To dissolve carbonates and to remove all exchangeable metal ions. The excess of HCl is then removed by filtration and washing, and the soil is dispersed in the presence of a small amount of a dispersing agent .

The removal of the cementing influences of the oxides of iron and alumina is a more difficult procedure (Mehra and Jackson, 1960) which removes free iron oxides with a minimum of destruction of the clay minerals. Sodium citrate serves as the chelating agent for ferrous and ferric forms of iron . The sodium bicarbonate buffers the solution ; while the sodium dithionite (also known as sodium hyposulfite or sodium hydrosulfite) reduces the iron. The following reagents are required :

1. Sodium citrate dihydrate, 0.3 M, 88 g / lit
2. Sodium bicarbonate ($NaHCO_3$), 1 N g / lit
3. Sodium dithionite ($Na_2S_2O_4$)
4. Sodium chloride ($NaCl$) solution, saturated
5. Acetone, reagent grade.

Procedure

A suitable sample of soil (4 to 5 g of soil) , free from organic matter, soluble salts, and preferably carbonates, is taken. The sample should not contain more than 0.5 g of extractable Fe_2O_3 / Add 40 ml of 0.3 M Na-citrate solution and 5 ml on 1N $NaHCO_3$ solution to the sample. Warm the suspension to $80^\circ C$ in a water bath, and then add 1 g of solid $Na_2S_2O_4$; stir the suspension constantly for 1 minute and Occasionally for a total of 15 minutes Avoid heating above $80^\circ C$ Following the 15 minutes digestion period, add 10 ml of a saturated $NaCl$ solution . If the suspension fails to flocculate with the $NaCl$, add 10 ml of acetone.

Mix the suspension , warm on a water bath if necessary, and centrifuge the tube for 10-15 minutes at 16,00 to 2,200 rpm. Repeat the above treatment once or twice for samples which originally contain more than 5% extractable Fe_2O_3 .

After removing the cementing agents, dispersion usually requires the addition of a reagent such as OH^- , Na_2CO_3 , $Na_2C_2O_4$ (sodium metaphosphate, calgon which is commercial preparation of $NaPO_3$ containing sufficient Na_2PO_3 to give pH of 8.3 in a 10% aqueous solution), $(NaPO_3)_6$ (sodium hexametaphosphate), or various mixtures of these in dilute concentration. Procedures for preparing sodium metaphosphate from monosodium phosphate have been described by Tyner (1940) and Kilmer and

Alexander(1949). They have also found the mixtures of NaPO_3 and Na_2CO_3 particularly effective for soil particles dispersion, and have made it possible to disperse calcareous soils without the prior removal of alkaline earth carbonates.

Finally, the particles must be separated by turbulent mixing using mechanical shakers or electric mixers. The dispersing machine, generally used, has a stirring rod or shaft on which new durable paddle can be screwed when the old one wears out. The motor has a speed of about 16,000 to 18,000 rpm running idle. The soil cup has an improved set of baffles inside indicator for attaching the cup properly to the mixer.

Pipette Method of Particle- Size Analysis : The Pipette Method of particle-size analysis is based on the rate of fall of solid particles in a liquid medium as expressed by Stoke's Law as described above. This method depends upon the fact that sedimentation eliminates from the depth 'h' in time 't' all particles having settling velocities greater than 'h/t', while retaining at that depth the original concentration of particles having settling velocities less than 'h/t'. The taking of a small volume element by a pipette at a depth 'h' at time 't' furnishes a sample from which all particles coarser than a particular size have been eliminated, and in which all particles finer than that size are present in the same amount as initially.

The method described here is that of kilmer and Alexander (1949) with minor modification.

Special Appratus

1. Pipette sampling apparatus.
2. Special pipette with capillary which permits the pipette to fill in 30 seconds under full suction (20ml or 25 ml size)
3. Sedimentation cabinet or constant temperature room.
4. Sieve shaker.
5. Electrically driven mixer.
6. Sieves, set 6, 7.5 cm diameter frame, with cover and pan. Sizes of openings:- 1.0 mm, 0.5 mm, 0.25 mm (60mesh), 0.077 mm (80mesh), 0.105 mm (140mesh) and 0.047 mm (300 mesh)
7. One litre graduated cylinders.

Samling and pretreatment

Take 10 to 50 gm (as desired) oven dry soil sample which has been passed through a 2 mm sieve previously. For convenience, air-dry soil sample can be used and soil moisture content can be determined separately to make necessary adjustment in the calculation.

Fractionation

After Complete dispersion of the soil sample, wash and filter the contaminating ions by the procedures described earlier. Then separate the sand fraction from silt and clay by washing the sample through 300 mesh sieve (Procedure described above) The silt and clay fractions are caught in a litre graduated cylinder, together with sufficient distilled water washings from the sieve to fill the one- litre cylinder upto the mark. Then set the cylinder in the sedimentation cabinet or constant temperature room on flat surface .

Dry the sieve and its contents at 105°C to 110°C. Transfer the sand fraction to a dry evaporating dish, breaking all lumps, and then to the nest of sieves. Fractionate by shaking for 5 minutes and each fraction.

After the suspension in the one liter graduating cylinder has come to a constant level, determine the temperature and stir the cylinder end over end several times and set down again on the flat surface in the sedimentation cabinet, noting the time.

To determine silt and clay, at appropriate time and depth (as calculated by the accompanying nomogram or Storke's equation) 20 ml to 25 ml suspension sample for materials less than 20µ , 5 µ and 2 µ are taken, using pipette rack. Put contents in weighing beakers and rinse pipette with distilled water in the same beaker after each sampling . Oven dry at to 105°C-110°C. And weigh. Always count time from the latest stirring. Always measure the sampling depth from the existing surface of the suspension, and not from the level used for an earlier sampling.

Calculation of Results

For routine analysis, percentage of silt and clay fractions can be calculated using the following equation :

$$\text{Percentage of a particular fraction} = \frac{\text{Dry Weight of pipette sample}}{\text{X Total volume suspension}} \times 100$$

$$\text{Percentage of a particular fraction} = \frac{\text{Volume of pipette used}}{\text{X Wt. Of the soil sample taken}} \times 100$$

However , for more precise work, the procedure outlined below can be adopted.

Let 'x' = dry wt. Of the pipette sample
 Y = volume of the pipette
 V = total volume of the suspension

Then the apparent (uncorrected) weight of the particles in the given (cumulative) size range can be calculated from x.v/y. Deduct the weight of dispersing agent per litre of suspension, using the data obtained by drying a 10ml sample of the reagent. The result will be the cumulative weight ΣW. Determine by difference the weights 'W' of the individual fractions.

Due to various losses such as loss in solution, acidification, washing, and sieving etc., the sum of sand, silt and clay fractions calculated will not be 100. Before final reporting convert the various fractions on the basis of 100 as follows:

Suppose in a soil sample , the various fractions calculated are as follows:

Sand	=	40 %
Silt	=	30 %
Clay	=	25 %
Total	=	95 %
Loss (100 - 95)	=	5 %

Then, in sand , the loss is $= \frac{5 \times 40}{100} = 2.0\%$

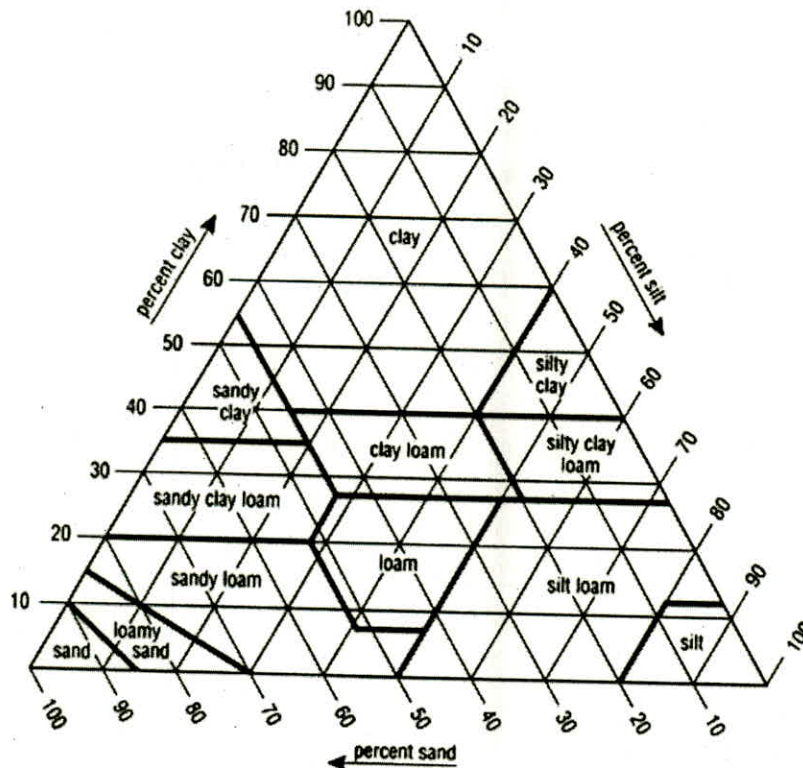
$$\begin{aligned} \text{Silt} &= \frac{5 \times 30}{100} = 1.5\% \\ \text{Clay} &= \frac{5 \times 25}{100} = 1.25\% \\ \text{Total} &= 4.75\% \\ \text{Difference } (5 - 4.75) &= 0.25\% \end{aligned}$$

Will be added to the fraction which is present in the greatest amount i.e. in sand in this case.
Hence, the various fractions to be reported will be:

Sand	=	40 + 2 + 0.25	42.25%
Silt	=	30 + 1.50	31.50%
Clay	=	25 + 1.25	26.25%
Total	=		100.00%

If however, the corrections for various losses are made as mentioned earlier, the sum of different fractions will add up to 100.

Finally, the textural class of the soil used for particle size distribution analysis can be derived from the triangular diagram (Fig. 1)



(Fig. 1)

PRACTICAL 12.
DETERMINATION OF IRON AND ALUMINIUM OXIDES (SESQUIOXIDES)
(A.O.A.C. METHOD)

Take 50 ml of the solution A in a beaker. Add 10 ml of HCl and a few drops of methyl red formed and the colour of indicator just changes to distinct allow. Boil not longer than 2 min and filter rapidly through a Whatman 40 filter paper. Wash the ppt. 6 to 8 times with hot 2% ammonium nitrate solution. Return the precipitate and filter to the original beaker. Add 10 ml of HCl and macerate the filter paper with a policeman, Dilute with later and heat to dissolve the ppt. Dilute to about 200 ml and re -precipitate is directed above . Wash thoroughly with the hot ammonium nitrate solution is above until free of chlorides. Combine the first and second filtrates and have them for Ca and Mg determinations.

Ignite the precipitate gently, cool and weigh . Calculate the percentage of sesquioxides.
 (F_2O_3 , Al_2O_3 , P_2O_5 and TiO_2).

If the percentage of P_2O_5 is subtracted from the total, then the remainder will be sesquioxides.

Calculations

Tare of crucible	=	W_1
Crucible + residue	=	W_2
Residue	=	$W_2 - W_1$
	=	$\frac{W_2 - W_1}{2} \times 100 = \text{say } Y$

Percentage of sesquioxides other than P_2O_5
 = $Y - (\%P_2 - O_1)$

Transfer the ignited precipitate to a 40 ml platinum crucible and add 5 to 7 g of potassium pyrosulphate. Heat very cautiously over the low flame of a burner. Fuse until all the solid matter is dissolved. If any matter adheres to the sides of the crucible after bubbling has in again into the melt by manipulation with tongs and flame. After is cool the melt as in the sodium carbonate fusion and add 4 ml of concentrated sulphuric acid, and dissolve in water, keeping the volume under 150 ml.

PRACTICAL 13.

Determination of Calcium (A. O.A.C. Method)

Material required

Equipment and glassware

- Beaker
- Filter pater (Whatman No. 40)

Reagents

- Ammonium chloride
- Ammonium hydroxide
- Ammonium oxalate
- Methyl red indicator
- HCl
- Sulfuric acid
- Potassium per manganate

Procedure

- Concentrate the combined filterate and washing to about 50 ml. Add about 5g of ammonium chloride. Make it slightly alkaline with NH_4OH (1+1).
- While still hot, add saturard solution of ammonium oxlate as long as any precipitate is formed and then add excess of it to convert the calcium ions in to calcium oxlate.
- Add two drops of methyl red indicator and then add either HCl (0.1N) or NH_4OH (1+4) till the colours turns light pink. Heat to boiling and allow to stand for 3 hours or longer.
- Decant the clear solution through filter paper Whatman No. 40. Wash the precipitate on the filter paper with hot water.
- Dissolve any precipitate remaining on the filter paper washing with HCl(1+10) in to the original beaker in which it was precipitated. Wash the filter paper with hot water 5-6 times to ensure the complete transfer of the precipitate to the original beaker.
- Reprecipitate by adding ammonium hydroxide and ammonium oxlate solution.
- Allow to stand as before and filter through the same filter paper. Wash it free from chlorides with hot water.
- Reserve the filterate and washings for the estimation of Mg.
- The precipitate of calcium oxlate may be dissolved in dilute sulphuric acid and titrated with N/20 KMnO_4 solution.

Calculations:

$$1\text{ml N/20 KMnO}_4 = 0.001 \text{ g Ca}$$

PRACTICAL 14.

Determination of Magnesium (A. O. A.C. Method)

Equipment and glassware

- Beaker (500ml)
- Filter paper (Whatman No. 40)
- Gooch crucible

Reagent

- Citric acid
- Ammonia solution
- Absolute alcohol
- Ammonium phosphate
- Ammonium nitrate

Procedure

- To the combined Mg filtrate and washing from Ca determination, add 2 ml of citric acid, 100ml of ammonia and 50ml of alcohol and then add with constant stirring 25 ml of 10% ammonium phosphate solution. Let it stand overnight.
- Filter the solution in to original beaker, make the volume to 100-150 ml. To this solution in to the original beaker, add 10-15 ml of ammonia and 2 drops of ammonium phosphate solution.
- Stir vigorously and allow to stand for 3 hours or longer, filter through a gooch crucible and wash with ammonia(1+9).
- Moisten filter paper with saturated ammonical solution of ammonum nitrate. Ignite the precipitate and weigh as $Mg_2P_2O_7$.
- Calculate the percentage of Mg as:

Calculations:

$$\text{Weight of Mg} = \text{Weight of } Mg_2P_2O_7 \times 0.2162$$

PRACTICAL 15. DETERMINATION OF TOTAL SULPHUR IN SOILS

Principle: The organic sulphur of soils is oxidized to sulphate by sodium peroxide followed by fusion with sodium carbonate to break down the soil minerals. The sulphate is determined by precipitation as barium sulphate.

Reagents and apparatus:

- Sodium peroxide
- Granular Sodium Carbonate
- Concentrated HCl
- Hydrochloric acid(1+10)
- Methyl red indicator
- Barium chloride (10%)
- Ethyl alcohol (95%)
- Sulphuric acid (1+2)
- 10% BaCl₂
- Nickel crucible

Procedure:

Fusion:

- Weigh 5 to 10 g of air-dry soil of 0.5 mm mesh in to a 50 ml nickel crucible. Add an equal weight of anhydrous sodium carbonate : mix, 2ml of water to the soil and stir well to a stiff paste.
- Immediately add 10 g in successive portion of sodium peroxide (about 1 g at a time) to avoid excessive frothing. Put it in the furnace for 30 minutes at 400 to 500°C: then raise rapidly to to bright red heat (about 900°C) and heat for about 10 minutes.
- Withdraw the crucible from muffle furnace, and place the crucible sideways in a 600 ml beaker and cover with distilled water.
- Add about 5 ml of ethyl alcohol and place it on a cold hot plate and heat. Remove the crucible and rod from the beaker.
- If small glassy particles still cling to the inside of the crucible, disintegrate them by adding water and boiling over a hot plate or small flame and add it to the main portion.
- Filter by suction through a 9 cm Buchner funnel in to a litre beaker or jar. When no more liquid can be drawn through the filter, return the residue together with filter paper to the original beaker, add about 1 g of sodium carbonate, macerate with 75 to 100 ml of water and bring to a brisk boiling.
- Again filter through a Buchner funnel using suction and wash with 20 ml portions of hot water to a total of 500 ml portions of hot water to a total of 500 ml. Make up the volume to 1 litre.
- Determine the amount of sulphate in the extract gravimetrically.

Precipitation of BaSO₄:

- The solution is brought to boiling, and 10 ml of 10% barium chloride(BaCl₂) is slowly added to precipitate the sulphate.
- The solution is allowed to stand until cool, then is passed through a small fine porosity filter paper, and the precipitate is washed.

Ignition of BaSO₄:

- The paper is ignited at low temperature and the precipitate weighed.
- The ignited BaSO₄ is treated with a few drops of HF and H₂SO₄, cautiously ignited, and weighed again.
- The reagents used invariably contain some sulphur, blanks are carried along in the same manner as the determinations.

Calculations:

$$\%S = \text{gm BaSO}_4 \times 13.7 / \text{Weight of sample}$$

PRACTICAL 16.
DETERMINATION OF TOTAL NITROGEN OF THE SOIL
(ALTERNATE METHOD)

Most of the nitrogen of the soil is present in organic combination, and very small amount occurs in nitrate and ammoniacal forms. For the determination of total nitrogen kjeldahl method is used. There are various modifications of it, but usually the soil, i.e., fine earth (0.5 mm diam) is digested with sulphuric acid in the presence of a mixture of potassium sulphate, ferrous sulphate and copper sulphate. From the ammonium salts thus formed, ammonia is distilled with sodium hydroxide and absorbed in a known excess of N/10 H₂SO₄. The excess of the acid left unneutralized can be determined by titration with standard alkali using methyl red indicator.

Reagents

1. Sulphuric acid (0.1 N).
2. Sodium hydroxide (0.1 N).
3. Methyl red indicator solution.
4. Salt mixture containing K₂SO₄ (10 Parts), FeSO₄ (1 part), CuSO₄ . 5H₂O (0.5 parts).
5. Salicylic acid.
6. Sodium thiosulphate.

Transfer 10 g of soil to a clean dry Kjeldahl flask. Moisten it with about 10 ml of water, shake well and allow it to settle for about 30 min. Add 35 ml of concentrated sulphuric acid and 10 g of mixture of K₂SO₄, Fe SO₄ and CuSO₄. Now add one gram of salicylic acid and 5 g Na₂S₂O₃. Heat first at a low flame and then gradually raise the flame. Continue digestion until the mixture is colourless or nearly so. Cool, and add about 50 ml water. Swirl well and cool under a tap. Transfer the solution by decantation to a 800 ml distillation flask. Wash the contents of the digestion flask with water till free from acid. Do not attempt to transfer the sandy material to the distillation flask. Make up volume to about 400 ml. Add a few pieces of porcelain or glass beads to prevent bumping. Distil as usual, receiving ammonia in a known volume of N/10 sulphuric acid (20ml). Titrate excess of the acid with N/ 10 NaOH using methyl red indicator. In the same way carry out a blank .

Calculations

$$1 \text{ ml of } 0.1 \text{ N H}_2\text{SO}_4 = 14 \times 0.1 \times \frac{1}{100} = 0.0014 \text{ g nitrogen}$$

Weight of soil taken for nitrogen estimation	=	10 g
Volume of 0.1 N H ₂ SO ₄ taken, i. e., blank value	=	V ₁ ml
Volume of 0.1 N NaOH required for neutralizing the excess of the acid	=	V ₂ ml
Volume of 0.1 N acid used up for neutralizing ammonia	=	V ₁ - V ₂
Percentage of nitrogen in the soil	=	$\frac{(V_1 - V_2) \times 0.0014 \times 100}{10}$

APPENDIX - I
I. INTERNATIONAL ATOMIC WEIGHTS

Element	Symbol	At.Wt.	Element	Symbol	At.Wt.
Aluminum	Al	26.97	Neon	Ne	20.183
Antimony	Sb	121.76	Nickel	Ni	58.69
Argon	A	39.944			
Arsenic	As	74.91	(Columbium)	Cb	92.91
Barium	Ba	137.36	Nitrogen	N	14.008
Beryllium	Be	9.02	Osmium	Os	190.0
Bismuth	Bi	209.00	Oxygen	O	16.00
Boron	B	10.92	Baltadium	pd	106.7
Bromine	Br	79.916	Phosphorus	P	30.98
Cadmium	Cd	112.41	Platinum	Pt	195.23
Caesium	Cs	132.91	Potassium	K	39.095
Calcium	Ca	40.08	Praseodymium	Pr	140.92
Carbon	C	12.01	Protoactinium	Pa	231
Cerium	Ce	140.13	Radium	Ra	226.05
Chlorine	Cl	35.457	Radon	Rn	222
Chromium	Cr	52.01	Rhenjum	Re	186.31
Cobalt	Co	58.94	Rhodium	Rh	102.91
Copper	Cu	63.57	Rubidium	Rb	85.46
Dysprosium	Dy	162.46	Ruthenium	Ru	101.7
Erbium	Er	167.2	Samarium	Sm	150.43
Europium	Eu	152.0	Scandium	Sc	45.10
Fluorine	F	19.00	Selenium	Se	78.96
Gadolinium	Gd	156.9	Silicon	Si	28.06
Gallium	Ga	69.72	Silver	Ag	107.880
Germanium	Ge	72.60	Sodium	Na	22.997
Gold	Au	197.2	Strontium	Sr	87.63
Hafnium	Hf	178.6	Sulphur	S	32.06
Helium	He	4.003	Tantalum	Ta	180.88
Holmium	Ho	163.50	Tellurium	Te	127.61
Hydrogen	H	1.008	Trbium	Tb	159.2
Indium	In	114.76	Thallium	Tl	204.39
Iodine	I	126.92	Thorium	Th	232.12
Iridium	Ir	193.1	Thulium	Tm	169.40
Iron	Fe	55.84	Tin	Sn	118.70
Krypton	Kr	83.7	Titanium	Ti	47.90

Lanthanum	La	138.92	Tungsten	W	183.92
Lead	Pb	207.21	Uranium	U	238.07
Lithium	Li	6.940	Vandadium	V	50.95
Lutecium	Lu	175.0	Xenon	Xe	131.30
Magnesium	Mg	24.32	Ytteeerbium	Yd	173.04
Manganese	Mn	54.93	Yttrium	Y	88.92
Mercury	Hg	200.61	Zinc	Zn	65.38
Molybdenum	Mo	95.95	Zirconium	Zr	91.22

APPENDEX - II

II. Normality, specific gravity and per cent by weight of acids acids and ammonia reagent in the laboratory

Sr. No.	Reagent	Normality N*	Specific gravity	MI required to make 1 litre of 1 N solution
•	Acetic acid glacial	17.4	1.05	58 ml
•	Hydrochloric acid cone	11.8	1.18	89 ml
•	Nitric acid Cone	16.0	1.42	63 ml
•	Sulphuric acid Cone	41.1	1.69	23 ml
•	Phosphoric acid Cone	36.0	1.84	28 ml
•	Perchloric acid	11.6	1.66	86 ml
•	Ammonium hydroxide Cone	14.3	0.90	71. ml
•	Phosphoric acid	44.4	1.71	

N* = normality approximate

Note : To prepare a diluted reagent from a concentrated one use the expression

$$V_1 = V_2 \times N_2 / N_1$$

Where,

V_1 Vol. of the cone Reagent required

V_2 Vol. of the diluted reagent

N_1 Normality of the cone. reagent

N_2 Normality of the diluted reagent

APPENDIX - III

III. Approximate pH values of some acid and alkali

Substance	Normality	pH	Substance	Normality	pH
HCl	1.0	0.1	NaOH	1.0	14.05
	0.1	1.07		0.1	14.07
	0.01	2.02		0.01	12.12
	0.001	3.01		0.001	11.13
Acetic acid	1.0	2.37	NH ₄ OH	1.0	11.6
	0.1	2.37		0.1	11.1
	0.01	3.37		0.01	10.6
	0.001	3.87		0.001	10.1
H ₂ SO ₄	0.1	1.2	Oxalic acid	0.1	1.6

APPENDIX - IV

PREPARATION OF 1000 PPM SOLUTION OF DIFFERENT ELEMENTS

S.N.	Element	Quantity of salt to be dissolved in 1000 ml distilled water.
1.	Nitrogen	4.719 g of (NH ₄) ₂ SO ₄ Ammonium sulphate 2.140 g urea CO (NH ₂) ₂
2.	Phosphorus	4.390 g of KH ₂ PO ₄ Pot. Dihydrogen Phosphate 5.555 g of CaHPO ₄ ·2H ₂ O, Dicalcium phosphate dihydrate 14.31 g of single superphosphate containing 6.986 % P
3.	Potassium	1.906 g Potassium Chloride (Murate of Potash) KC ₁ ,
4.	Zinc (Zn)	4.398 g Zinc sulphate ZnSO ₄ ·7H ₂ O,
5.	Manganese	3.609 g Manganese chloride, MnCl ₂ ·2H ₂ O (Mn) 3.077 g Manganese sulphate MnSO ₄ ·H ₂ O
6.	Copper (Cu)	3.929 g Copper sulphate CuSO ₄ ·H ₂ O
7.	Iron (Fe)	4.978 g* FeSO ₄ ·7H ₂ O Ferrous sulphate (NH ₄) ₂ Fe(SC ₄) ₂ ·6H ₂ O
8.	Molybdenum	12.139 g Ammo. Molybdate (NH ₄) ₆ Mo ₇ O ₂₄ ·4H ₂ O 2.521 G of Sodium molybdate Na ₂ MoO ₄ ·2H ₂ O
9.	Boron	5.720 Boric acid H ₃ BO ₃

- Add 15 ml of concentration sulphuric acid in solution and then make volume to one litre.

APPENDIX - V

STANDARD SOLUTION: The solution of accurately known strength (or concentration) is called a standard solution. It contains a definite number of gram equivalent or gram moles per litre of solution. Strength of a solution refers to the weight of a solute dissolved in a unit weight of the solution. It can be expressed in many ways as follows:

NORMAL SOLUTION AND NORMALITY: A normal solution is one which contains 1 gram equivalent (equivalent weight in grams) of the active reagent dissolved in one litre of the solution. Normality is the number of gram equivalent of the substance, dissolved in one litre of the solution. If the number of gram equivalent in one, it is expressed as 1 N. If the number is 1/10, 1/100 or 1/1000 then it is designated as 0.1 (decinormal), 0.01 N (centinormal) or 0.001 N (millinormal) solution respectively.

$$\text{Normality} = \frac{\text{Number of gram equivalents of solute}}{\text{Number of litre of Solution}}$$

MOLAR SOLUTION AND MOLARITY: A molar solution is one which contains a gram molecular weight of the solute dissolved in 1 litre of solution. M denotes it whereas, molarity is the number of gram molecules of the substance dissolved in 1 litre of the solution.

MOLAL SOLUTION: A Molal solution is the one which contains a number of gram molecules of the solute dissolved in 100 g of solvent.

PERCENTAGE COMPOSITION BY WEIGHT : The concentration is expressed in terms of volume of the solute per 100 g of solution. E. g. a 10% KCl solution is prepared by dissolving 10 g of the salt in 90 of water.

PERCENTAGE COMPOSITION BY VOLUME: The concentration is expressed in terms of volume of the solute and solvent. E.g. 25% solution of methanol is prepared by mixing 25 ml of methanol with 80 ml of water.

PART PER MILLION (PPM): The concentration is expressed in terms of grams of solute per million milliliters of solution or milligrams of solute per litre of the solution.

Thus a solution containing 10 mg/ litre of solute or 10 microgram (g) of solute per milliliter of solution is 10 - ppm solution.

MILLI EQUIVALENT PER LITRE: A solution containing milli (1/1000) g equivalent of substance in a litre of the solution is expressed as meq/ litre.

TITRATION : titration is defined as the process of determining the volume of a substance required to just complete the reaction with a known amount of other substance. the quantitative analysis carried out by titration is known as titrimetric analysis.

- a) Titration : The solution of accurately known strength used in titration is called titrant.
- b) Titrate: The substance (in solution) to be determined by titration is called titrate.

EQUIVALENT OR END POINT: The end point (in burette reading) at which the reaction is just complete in titration is called equivalent point or end point. At this, volume of titration reaction is completed quantitatively with a known volume of titrate.

APPENDIX - V

Some important Conversion factors

To Convert Column -1 to column-2 <i>Multiply by the factor</i>	Column- 1	Column- 2	To Convert Column -2 to column -1 <i>Multiply by the factor</i>
0.892	Kg/ha	1b/acre	1.121
220.2	quintal	1bs	0.00454
2.205	Kg	1b	0.454
1.094	meter	yard	0.914
0.394	cm	inch	2.540
2.29	P	P ₂ O ₅	0.437
1.20	K	K ₂ O	0.830
1.39	Ca	CaO	0.715
1.66	Mg	MgO	0.602
2.24	ppm	Kg/ha	0.446
0.10	g/Kg	percent	10.00
0.0001	ppm	percent	10000.00
22.4	mg/100g	kg/ha	0.0446
10.	mg/100g	ppm	0.10
(9.0/5.00C)+32	°C	°F	5.00/9.0(°F-32)

ppm = milliequivalent per litre x eq. wt.
 = microgram per ml or mg per litre
 meq. per litre = ppm/ equivalent wt.

